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Title	:	WATER PRESSURE SYSTEM WITH PRESSURE TANK INSTALLED WITHIN WELL CASING OF WELL
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EXPRESS MAIL Mailing Label Number EL 914987699 US Date of Deposit February 25, 2002 I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" Service under 37 CFR 1.10 on the date indicated above and is addressed to the Assistant Commissioner of Patents, Washington, D.C. 20231 William K. Baxter (Typed or printed name of person mailing paper or fee) William K. Baxter (Signature of person mailing paper or fee)	William K. Baxter Registration No. 41,606 GODFREY & KAHN, S.C. 780 North Water Street Milwaukee, Wisconsin 53202 Tel.: 414-273-3500 Fax: 414-273-5198 Email: Wbaxter@gklaw.com

WATER PRESSURE SYSTEM WITH PRESSURE TANK INSTALLED WITHIN WELL CASING OF WELL

Cross-Reference To Related Applications

This application is a continuation-in-part of Application No. 09/428,343, filed October 27, 1999, the disclosure of which is incorporated herein by reference.

Background of the Invention

The present invention relates to water pressure systems for water wells, and more particularly, to a pressure tank installed underground within the well casing of a well for storing water under pressure for distribution and use.

A typical water pressure system for residential use is established by first drilling a hole in the ground in search of water from a water bearing aquifer. Once water is reached by the drill, a well casing is inserted into the bore hole to preserve the sides of the well. A submersible pump is then inserted into the well below the water level to pump water from the aquifer. One end of a drop pipe is attached to the submersible pump to draw water out of the well. The other end of the drop pipe is attached to a pitless adapter, which is attached to a discharge pipe for carrying water to a pressure tank located outside above ground or inside a building.

The pressure tank holds a reserve supply of water under pressure within the tank. A pressure switch coupled to the tank is used to maintain water pressure in tank between a minimum value and a maximum value. The water is stored in the tank under pressure until it is needed. As water is drawn from the tank, the pressure in the tank decreases. The pressure switch activates the submersible pump to pump water into the tank when the water pressure in the tank drops below the minimum value. As water is pumped back into the tank, pressure in the

tank increases to the maximum value. When the pressure reaches the maximum value, the pressure switch stops the pump from pumping water into the tank.

Pressure tanks are normally of substantial size, and consequently are limited to above ground installations in most water pressure systems. Typically, pressure tanks are installed outside above ground, in the basement of a house or in a separate building to protect it from the elements. Adverse weather conditions can effect the reliability of a pressure tank in cold weather climates. During the winter months, the pressure tanks must be protected from the cold and snow. Therefore, the pressure tanks for use in cold weather climates are either installed in a basement or in an insulated building above ground.

However, there are problems associated with above ground installations of pressure tanks. The large pressure tanks are usually quite expensive, cumbersome and difficult to install. The installation of a pressure tank above ground in cold weather climates may lead to freezing problems that require the tank be wrapped in insulation and heat tape or require the tank be installed in the basement of a house or a separate insulated building. Installation of a pressure tank in the basement or other area of a house takes up valuable space in the home. And installation of a pressure tank in a separate insulated building would require construction of the building. Thus, the installation of a pressure tank is often quite difficult and time-consuming.

Water pressure tanks installed underground are known in the art. For example U.S. Patent 3,394,733 to Jacuzzi discloses an airless water pressure system utilizing an underground pressure tank. The pressure tank of this invention includes an expansible tube installed around a pipe having openings therein to transfer liquid from the pipe to the expansible tube. The tube is clamped at each end to allow the liquid under pressure to cause expansion of the tube. However,

the clamped ends of the tube have been known to fail under pressure from the liquid. In another patent to Jacuzzi, U.S. Patent 3,442,292 discloses a pressure tank installed underground in a well, having water flowing into the pressure tank around an air filled bladder. The problem with this patented invention is that the air filled bladder seals off water flow from the inlet end of the tank to the outlet end of the tank. In other words, water freely flows into the tank but is sealed off from exiting the tank by the air filled bladder pressing against the walls of the tank. Also, the pressure tank is positioned at the top of the well, which could cause freezing problems in cold climates.

Accordingly, there is a need for a water pressure system that allows for installation of a pressure tank underground in the well casing of a well that is less expensive, easier to install and maintain, and more reliable than prior art water pressure systems.

Summary of the Invention

The present invention provides a pressure tank installed within the well casing of a well. The pressure tank having an outside diameter to fit inside a well casing having an inner diameter greater than the outside diameter of the pressure tank.

The water pressure system of the present invention pumps water from a water bearing aquifer to a pressure tank installed underground within the well casing of a well. The water pressure system of the present invention includes several different embodiments. A first embodiment includes a submersible pump installed in the well below the water level to pump water from the aquifer. One end of a first drop pipe is attached to the submersible pump, while the other end of the first drop pipe is attached to an inlet end of a pressure tank installed in the well casing of the well. Water flows from the submersible pump through the drop pipe and into

the pressure tank. The water enters the pressure tank through an inlet opening, and is either stored in the tank for future use, or continues to flow out through an outlet opening in the tank. One end of a second drop pipe is connected to an outlet end of the tank. The other end of the second drop pipe is connected to a discharge pipe for distribution of water from the well.

A first embodiment of the pressure tank includes a main body having an inlet end, an outlet end, and an outer sidewall. Attached to the inlet end of the tank are an inlet end cap and an inlet plug. The inlet plug is inserted within the inlet end cap. A flexible diaphragm bladder is connected between the inlet plug and the outlet end cap. A center pipe extends through the center of the flexible diaphragm bladder between an inlet opening and an outlet opening. The center pipe has a plurality of holes therein to allow water to flow through the tube and into and out of the flexible bladder. The inlet opening of the diaphragm bladder is clamped to a ribbed end of the inlet plug with a clamping device. The outlet opening of the diaphragm bladder is clamped to a ribbed end of the outlet end cap with a similar clamping device. Pressurized air fills the empty space between the bladder and the outer sidewall of the tank to pressurize the water in the flexible bladder.

The outlet end of the drop pipe opposite the end connected to the submersible pump is connected to the inlet plug extending through the inlet end cap of the pressure tank. The other end of the inlet plug is connected to the inlet end of the diaphragm bladder. The outlet end of the diaphragm bladder is attached to the outlet end cap. Water flows through the openings in the inlet end cap, inlet plug, diaphragm bladder, and outlet end cap to a second drop pipe connected to the outlet end cap of the tank. The other end of the second drop pipe may be connected to a pitless adapter, which in turn is connected to a discharge pipe.

A pressure switch coupled to the pressure tank regulates water pressure in the pressure tank by maintaining the water pressure between a minimum value and a maximum value. The pressure switch continuously monitors the water pressure in the tank, and controls the submersible pump accordingly. The pressure switch responds to a drop in pressure below the minimum value by starting the pump to replenish the water in the tank and to build up the water pressure to its maximum value. The pressure switch stops the pump when the water pressure reaches the maximum value and restarts the pump when the pressure drops below the minimum value.

The first embodiment may be used in combination with a relief valve and a flow control valve, a flow control valve with an integral relief valve incorporated therein, or a submersible variable speed pump.

A second embodiment of a pressure tank includes a tank with water on the outside of the bladder. The original tank, with water on the inside of the bladder, is preferably used in wells having an outer diameter of five inches or more, preferably five to six inches. This second embodiment with water on the outside of the bladder is preferably used in wells having an outer diameter of less than five inches, preferably three to four inches. This embodiment does not include a center pipe extending through the center of the tank, yet provides the same amount of storage capacity as the first embodiment. The second embodiment is also easier and less expensive to manufacture, install, repair, and/or replace than the first embodiment.

The second embodiment may also be used in combination with a relief valve and a flow control valve, a flow control valve with an integral relief valve incorporated therein, or a submersible variable speed pump.

The present invention also contemplates new methods and apparatus for attaching or sealing bladder to the pressure tank ends. In one embodiment, the bladder is held in place at the top and bottom ends with clamps. At least one clamp is strapped around the bladder at the top and bottom ends of the tank. In another embodiment, the top and bottom of the bladder are sealed between flexible fittings at the ends of the tank. This design allows for easy repair and/or replacement of the bladder. The bladder is replaced by removing the top of the tank, undoing the clamps and/or fittings, and lifting the bladder out. This design is also easier to construct and install than other designs. In yet another embodiment, the bladder includes end caps at the top and bottom. Brackets attach the end caps to the top and bottom of the tank. At least one clamp is attached around the bladder at the top and bottom end caps, securing the bladder in place. An anchor system attaches the bottom end cap to the bottom of the tank and prevents the bladder from moving to the top of the tank.

The present invention provides a constant flow of water through the system and prevents the pump from cycling on and off from irregular or intermittent use. The present invention may also be used in liquid systems other than water, such as fuel dispensing systems.

Various other features, objects, and advantages of the invention will be made apparent to those skilled in the art from the following drawings and detailed description of the invention.

Brief Description of the Drawings

FIG. 1A is a partial cross-sectional schematic representation of a water pressure system according to a first embodiment of the present invention, showing a pressure tank installed within the well casing of a well at maximum storage capacity;

FIG. 1B is a partial cross-sectional schematic representation of the water pressure system of FIG. 1A, showing the pressure tank at minimum storage capacity;

FIG. 2A is a partial cross-sectional schematic representation of a water pressure system according to a second embodiment of the present invention, showing a pressure tank installed within the well casing of a well at maximum storage capacity;

FIG. 2B is a partial cross-sectional schematic representation of the water pressure system of FIG. 2A, showing the pressure tank at minimum storage capacity;

FIG. 3A is a partial cross-sectional schematic representation of a water pressure system, according to a third embodiment of the present invention, showing a pressure tank installed within the well casing of a well at maximum storage capacity;

FIG. 3B is a partial cross-sectional schematic representation of the water pressure system of FIG. 3A, showing the pressure tank at minimum storage capacity;

FIG. 4 is a partial cross-sectional view of a first embodiment of a pressure tank according to the present invention;

FIG. 5 is an enlarged partial cross-sectional view of the inlet end of the pressure tank of FIG. 4;

FIG. 6 is an enlarged exploded view of the components of the inlet end cap of the of the inlet end of FIG. 5;

FIG. 7 is an enlarged partial cross-sectional view of the outlet end of the pressure tank of FIG. 4;

FIG. 8 is an enlarged view of the outlet end cap of the outlet end of FIG. 7;

FIG. 9A is an enlarged partial cross-sectional view of an alternative embodiment of an inlet end of a pressure tank;

FIG. 9B is an enlarged partial cross-sectional view of an alternative embodiment of an outlet end of a pressure tank;

FIG. 10A is a partial cross-sectional schematic representation of a water pressure system similar to the water pressure system of FIG. 1A, showing an alternate embodiment of a pressure tank installed within the well casing of a well at maximum storage capacity;

FIG. 10B is a partial cross-sectional schematic representation of the water pressure system of FIG. 10A, showing the pressure tank at minimum storage capacity;

FIG. 11A is a partial cross-sectional schematic representation of a water pressure system similar to the water pressure system of FIG. 2A, showing an alternate embodiment of a pressure tank installed within the well casing of a well at maximum storage capacity;

FIG. 11B is a partial cross-sectional schematic representation of the water pressure system of FIG. 11A, showing the pressure tank at minimum storage capacity;

FIG. 12A is a partial cross-sectional schematic representation of a water pressure system similar to the water pressure system of FIG. 3A, showing an alternate embodiment of a pressure tank installed within the well casing of a well at maximum storage capacity;

FIG. 12B is a partial cross-sectional schematic representation of the water pressure system of FIG. 12A, showing the pressure tank at minimum storage capacity; and

FIG. 13 is a cross-sectional view of the pressure tank of FIGS. 10A, 10B, 11A, 11B, 12A and 12B taken along line 13-13 of FIG. 10A.

Detailed Description of the Invention

FIGS. 1A and 1B illustrate a schematic representation of one embodiment of a water pressure system 10 comprising a pressure tank 12 installed within the well casing 14 of a well 16. FIG. 1A shows the tank 12 at a maximum storage capacity, while FIG. 1B shows the tank 12

at a minimum storage capacity. The pressure tank 12 can vary in size, but must have a small enough outer diameter to fit inside the inner diameter of the well casing 14. Most well casings have an inner diameter that range from approximately three to eight inches. The pressure tank embodiments of the present invention preferably have an outer diameter that range from approximately three to seven inches and have a length of up to ten feet or more. The pressure tank can be placed at any depth in the well and has a typical draw down storage capacity of approximately one to three gallons. A first pressure tank embodiment that stores water on the inside of a flexible diaphragm bladder, as shown in FIGS. 1A, 1B, 2A, 2B, 3A, 3B, 4, 5, 7, 9A and 9B, is preferably designed for well casings having an inner diameter of approximately five inches or more. Another pressure tank embodiment that stores water on the outside of the flexible diaphragm bladder, as shown in FIGS. 10A, 10B, 11A, 11B, 12A, 12B and 13, is preferably designed for well casings having an inner diameter of approximately less than five inches. The pressure tank embodiments of the present invention are reduced in size, more reliable, less expensive to manufacture and install, and more easily maintained than prior art pressure tanks.

The water pressure system of the present invention preferably operates within a specific range of pressure. The pressure range is achieved with a pressure switch, which turns on the pump when the pressure reaches a preset minimum value and turns off the pump when the pressure reaches a preset maximum value. Water that enters the pressure tank is either stored under pressure in the tank for future use, or continues to flow out through the tank to a discharge pipe for distribution and use. As water is drawn from the system, water is released from the pressure tank, and the pressure drops to the minimum pressure level, causing the pressure switch

to close, starting the pump to refill the pressure tank. As the pressure tank is filled, the pressure increases to the maximum pressure level and the pressure switch opens, stopping the pump.

The water pressure system 10 of FIGS. 1A and 1B, comprises a submersible pump 18 installed in a well 16 for pumping water from a water bearing aquifer 20 through a relief valve 32 and a flow control valve 36 to a pressure tank 12 installed in the well casing 14 of the well 16. Water from the pressure tank 12 flows to a discharge pipe (not shown) for distribution and use.

The output 28 of the submersible pump 18 is connected to the relief valve 32. The relief valve 32 is preferably installed below the pumping water level 24 right above the submersible pump 18, so that the relief valve 32 is always under water, preventing mineral deposits from forming on the relief valve 32 that could adversely affect water quality. The relief valve 32 releases excess pressure in the system and limits back pressure from building up in the submersible pump, especially on the motor bearings of the pump, which could fail if the relief valve was not installed in the system. A first drop pipe 26 preferably connects the relief valve 32 to the flow control valve 36. The flow control valve 36 controls output flow from the pump 18 and relief valve 32. The flow control valve 36 maintains constant water pressure in the system and automatically adjusts the pump's output to match the flow requirements of the system. The flow control valve 36 also extends pump life by eliminating pump cycling, eliminating changes in water pressure and eliminating the need for a large storage pressure tank. A tank inlet drop pipe 38 connects the flow control valve 36 to the inlet end 40 of the pressure tank 12. A tank outlet drop pipe 44 preferably connects the outlet end 42 of the pressure tank 12 to a discharge pipe (not shown) for distributing pressurized water from the pressure tank 12.

The pressure tank 12 comprises an outer sidewall 54 with an inlet end 40 and an outlet end 42, a center pipe 56 extending through the inlet end 40, outlet end 42 and outer sidewall 54, and a flexible diaphragm bladder 58 surrounding the center pipe 56. The inlet end 40 and the outlet end 42 are sealed to the outer sidewall 54 at both ends of the pressure tank 12. The flexible diaphragm bladder 58 separates the inner space 60 of the tank 12 into an air chamber 62 on the outside of the flexible diaphragm bladder 58, and a water chamber 64 on the inside of the flexible diaphragm bladder 58 surrounding the center pipe 56. The center pipe 56 includes a plurality of openings 66 extending therethrough to allow water to flow into and out of the water chamber 64 as pressure in the tank 12 varies. These openings 66 allow water to enter the water chamber 64 on an increase in system pressure, and allow water to exit the water chamber 64 on a decrease in system pressure. As the system pressure increases, the flexible diaphragm bladder 58 expands into the air chamber allowing for the storage of water in the water chamber 64, as is shown in FIG. 1A. As the system pressure decreases, the pressurized air chamber 62 forces the flexible diaphragm bladder 58 to contract, forcing water out through the plurality of openings 66 in the center pipe 56 to the discharge pipe (not shown), as is shown in FIG. 1B. The flexible diaphragm bladder 58 is sealed to the inlet end 40 of the tank 12 with at least one bottom clamp 68 and is sealed to the outlet end 42 of the tank 12 with at least one top clamp 70, as shown in FIGS. 4, 5 and 7. The details of attaching and sealing the flexible diaphragm bladder to the inlet and outlet ends of the tank are discussed below in relation to FIGS. 4-8. Alternative embodiments for attaching and sealing the flexible diaphragm bladder to the inlet and outlet ends of the tank are shown in FIGS. 9A, 9B, 10A, 10B, 11A, 11B, 12A and 12B. The air chamber 62 in the tank 12 surrounding the flexible diaphragm bladder 58 is pre-charged with pressurized air to a preset amount depending on the desired operating pressure. An air line 72 extends through

the outlet end 42 of the tank 12 into the air chamber 62 and is coupled to an air valve 74 for charging the air chamber 62 with pressurized air. A pressure switch 22 is also coupled to the air line 72 to monitor the pressure within the air chamber 62 of the tank 12 and to control operation of the submersible pump 18 by turning it off and on according to pressure changes in the system.

The pressure switch 22 coupled to the pressure tank 12 regulates water pressure in the system by maintaining the water pressure between a preset minimum value and a preset maximum value. The pressure switch 22 continuously monitors the pressure and controls the submersible pump 18 accordingly. The pressure switch 22 responds to a drop in pressure below the minimum value by starting the pump 18 to replenish the water in the tank 12 and to build up the water pressure to the maximum value. The pressure switch 22 stops the pump 18 when the water pressure reaches the maximum value and restarts the pump 18 when the pressure drops below the minimum value.

FIGS. 2A and 2B illustrate a schematic representation of another embodiment of a water pressure system 30 having a pressure tank 12 installed within the well casing 14 of a well 16. FIG. 2A shows the tank 12 at maximum storage capacity, while FIG. 2B shows the tank 12 at minimum storage capacity. This embodiment includes the use of a flow control valve 76 with an integral relief valve 78 incorporated therein.

The water pressure system 30 of FIGS. 2A and 2B, comprises a submersible pump 18 installed in a well 16 for pumping water from a water bearing aquifer 20 through a flow control valve 76 with an integral relief valve 78 to a pressure tank 12 installed in the well casing 14 of the well 16. Water from the pressure tank 12 flows to a discharge pipe (not shown) for distribution and use.

The output 28 of the submersible pump 18 is connected to the flow control valve 76 with integral relief valve 78. The flow control valve 76 with integral relief valve 78 is preferably installed below the pumping water level 24 right above the submersible pump 18, so that the flow control valve 76 with integral relief valve 78 is always under water, preventing mineral deposits from forming on the relief valve 78 that could adversely affect water quality. The relief valve 78 releases excess pressure in the system and limits back pressure from building up in the submersible pump, especially on the motor bearings of the pump, which could fail if the relief valve was not installed in the system. The flow control valve 76 controls output flow from the pump 18. The flow control valve 76 maintains constant water pressure in the system and automatically adjusts the pump's output to match the flow requirements of the system. The flow control valve 76 also extends pump life by eliminating pump cycling, eliminating changes in water pressure and eliminating the need for a large storage pressure tank. A tank inlet drop pipe 38 connects the flow control valve 76 with integral relief valve 78 to the inlet end 40 of the pressure tank 12. A tank outlet drop pipe 44 preferably connects the outlet end 42 of the pressure tank 12 to a discharge pipe (not shown) for distributing pressurized water from the pressure tank 12.

The pressure tank 12 comprises an outer sidewall 54 with an inlet end 40 and an outlet end 42, a center pipe 56 extending through the inlet end 40, outlet end 42 and outer sidewall 54, and a flexible diaphragm bladder 58 surrounding the center pipe 56. The inlet end 40 and the outlet end 42 are sealed to the outer sidewall 54 at both ends of the pressure tank 12. The flexible diaphragm bladder 58 separates the inner space 60 of the tank 12 into an air chamber 62 on the outside of the flexible diaphragm bladder 58, and a water chamber 64 on the inside of the flexible diaphragm bladder 58 surrounding the center pipe 56. The center pipe 56 includes a

plurality of openings 66 extending therethrough to allow water to flow into and out of the water chamber 64 as pressure in the tank 12 varies. These openings 66 allow water to enter the water chamber 64 on an increase in system pressure, and allow water to exit the water chamber 64 on a decrease in system pressure. As the system pressure increases, the flexible diaphragm bladder 58 expands into the air chamber allowing for the storage of water in the water chamber 64, as is shown in FIG. 2A. As the system pressure decreases, the pressurized air chamber 62 forces the flexible diaphragm bladder 58 to contract, forcing water out through the plurality of openings 66 in the center pipe 56 to the discharge pipe (not shown), as is shown in FIG. 2B. The flexible diaphragm bladder 58 is sealed to the inlet end 40 of the tank 12 with at least one bottom clamp 68 and is sealed to the outlet end 42 of the tank 12 with at least one top clamp 70, as shown in FIGS. 4, 5 and 7. The details of attaching and sealing the flexible diaphragm bladder to the inlet and outlet ends of the tank are discussed below in relation to FIGS. 4-8. Alternative embodiments for attaching and sealing the flexible diaphragm bladder to the inlet and outlet ends of the tank are shown in FIGS. 9A, 9B, 10A, 10B, 11A, 11B, 12A and 12B. The air chamber 62 in the tank 12 surrounding the flexible diaphragm bladder 58 is pre-charged with pressurized air to a preset amount depending on the desired operating pressure. An air line 72 extends through the outlet end 42 of the tank 12 into the air chamber 62 and is coupled to an air valve 74 for charging the air chamber 62 with pressurized air. A pressure switch 22 is also coupled to the air line 72 to monitor the pressure within the air chamber 62 of the tank 12 and to control operation of the submersible pump 18 by turning it off and on according to pressure changes in the system.

The pressure switch 22 coupled to the pressure tank 12 regulates water pressure in the system by maintaining the water pressure between a preset minimum value and a preset maximum value. The pressure switch 22 continuously monitors the pressure and controls the

submersible pump 18 accordingly. The pressure switch 22 responds to a drop in pressure below the minimum value by starting the pump 18 to replenish the water in the tank 12 and to build up the water pressure to the maximum value. The pressure switch 22 stops the pump 18 when the water pressure reaches the maximum value and restarts the pump 18 when the pressure drops below the minimum value.

FIGS. 3A and 3B illustrate a schematic representation of yet another embodiment of a water pressure system 80 having a pressure tank 12 installed within the well casing 14 of a well 16. FIG. 3A shows the tank 12 at maximum storage capacity, while FIG. 3B shows the tank 12 at minimum storage capacity. This embodiment does not include the use of a relief valve or a flow control valve. Constant water pressure is maintained in the system through the use of a submersible variable speed pump 82.

The water pressure system 80 of FIGS. 3A and 3B, comprises a submersible variable speed pump 82 installed in a well 16 for pumping water from a water bearing aquifer 20 to a pressure tank 12 installed in the well casing 14 of the well 16 for distribution and use. A tank inlet drop pipe 38 preferably connects the output 84 of the submersible variable speed pump 82 to the inlet end 40 of the pressure tank 12. A tank outlet drop pipe 44 preferably connects the outlet end 42 of the pressure tank 12 to a discharge pipe (not shown) for distributing pressurized water from the pressure tank 12.

The pressure tank 12 comprises an outer sidewall 54 with an inlet end 40 and an outlet end 42, a center pipe 56 extending through the inlet end 40, outlet end 42 and outer sidewall 54, and a flexible diaphragm bladder 58 surrounding the center pipe 56. The inlet end 40 and the outlet end 42 are sealed to the outer sidewall 54 at both ends of the pressure tank 12. The

flexible diaphragm bladder 58 separates the inner space 60 of the tank 12 into an air chamber 62 on the outside of the flexible diaphragm bladder 58, and a water chamber 64 on the inside of the flexible diaphragm bladder 58 surrounding the center pipe 56. The center pipe 56 includes a plurality of openings 66 extending therethrough to allow water to flow into and out of the water chamber 64 as pressure in the tank 12 varies. These openings 66 allow water to enter the water chamber 64 on an increase in system pressure, and allow water to exit the water chamber 64 on a decrease in system pressure. As the system pressure increases, the flexible diaphragm bladder 58 expands into the air chamber allowing for the storage of water in the water chamber 64, as is shown in FIG. 3A. As the system pressure decreases, the pressurized air chamber 62 forces the flexible diaphragm bladder 58 to contract, forcing water out through the plurality of openings 66 in the center pipe 56 to the discharge pipe (not shown), as is shown in FIG. 3B. The flexible diaphragm bladder 58 is sealed to the inlet end 40 of the tank 12 with at least one bottom clamp 68 and is sealed to the outlet end 42 of the tank 12 with at least one top clamp 70, as shown in FIGS. 4, 5 and 7. The details of attaching and sealing the flexible diaphragm bladder to the inlet and outlet ends of the tank are discussed below in relation to FIGS. 4-8. Alternative embodiments for attaching and sealing the flexible diaphragm bladder to the inlet and outlet ends of the tank are shown in FIGS. 9A, 9B, 10A, 10B, 11A, 11B, 12A and 12B. The air chamber 62 in the tank 12 surrounding the flexible diaphragm bladder 58 is pre-charged with pressurized air to a preset amount depending on the desired operating pressure. An air line 72 extends through the outlet end 42 of the tank 12 into the air chamber 62 and is coupled to an air valve 74 for charging the air chamber 62 with pressurized air. A flow switch 110 and pressure transducer 112 are coupled to the discharge pipe 52 for use in connection with the submersible variable speed pump 82 as is known in the art.

Referring now to FIG. 4, a first embodiment of a pressure tank according to the present invention is shown. This embodiment is equivalent to the pressure tank shown in FIGS. 1A, 1B, 2A, 2B, 3A and 3B. FIGS. 4-8 illustrates the details of pressure tank 12 and of attaching and sealing the flexible diaphragm bladder 58 to the inlet 40 and outlet 42 ends of the tank 12.

As mentioned previously, a first drop pipe 38 connected to the output 28 of the submersible pump 18 is preferably attached to an inlet end 40 of the pressure tank 12 installed in the well casing 14 of the well 16. A second drop pipe 44 preferably connects the outlet end 42 of the pressure tank 12 to a pitless adapter 50 which is further connected to a discharge pipe 52.

The pressure tank 12 includes an outer sidewall 54 with an inlet end 40 and an outlet end 42. The inlet end 40 and the outlet end 42 are sealed to the outer sidewall 54 at both ends of the pressure tank 12. Connected between the inlet end 40 and the outlet end 42 is a flexible diaphragm bladder 58. A center pipe 56 extends through the center of the tank 12 inside of the flexible diaphragm bladder 58 from the inlet end 40 to the outlet end 42 of the tank 12. The center pipe 56 includes a plurality of openings 66 extending therethrough to allow water to flow into and out of the flexible diaphragm bladder 58 as pressure in the system varies. The bladder 58 preferably includes an inlet opening 88 at an inlet end 92 and an outlet opening 90 at an outlet end 94. The inlet opening 88 of the flexible diaphragm bladder 58 is sealed to the inlet end 40 of the tank 12 with at least one bottom clamp 68, and the outlet opening 90 of the flexible diaphragm bladder 58 is sealed to the outlet end 42 of the tank 12 with at least one top clamp 70.

FIGS. 5 and 6 illustrate the inlet end 40 of the tank 12. FIG. 5 is an enlarged partial cross-sectional view of the inlet end 40 of the pressure tank 12, while FIG. 6 is an enlarged exploded view of the components of the inlet end 40. The inlet end 40 of the tank 12 preferably

includes a cylindrically-shaped, hollow inlet end cap 96 and a cylindrically-shaped, hollow inlet plug 98. The inlet plug 98 is inserted within and mates with and extends through the inlet end cap 96. The inlet end cap 96 includes a bottom flange 100 and a cylindrical top portion 102 with standard pipe threads formed on the cylindrical top portion 102 for attachment to a bottom portion 104 of the outer sidewall 54 of the pressure tank 12. The bottom portion 104 of the outer sidewall 54 having mating pipe threads formed on the inner surface thereof for mating with the inlet end cap 96. The inlet end cap 96 is preferably screwed into the bottom portion 104 of the outer sidewall 54. An o-ring 106 located on an inner portion of the flange 100 seals the end cap 96 to the bottom portion 104 of the outer sidewall 54. Inserted within the inlet end cap 96 is an inlet plug 98, having a first end 108 for attachment to the first drop pipe 38 and a second end 110 for attachment to an inlet end 92 of the flexible bladder 58 within the tank 12. The first end 108 having threads for attachment of a fastener 112 to secure the inlet plug 98 in place within the inlet end cap 96. The second end 110 of the plug 98 includes a plurality of ribs 114 for connecting the inlet end 92 of the bladder 58 to the plug 98. At least one clamping device 116 fits over the ribs 114 of the second end 110 of the plug 98 to secure the inlet end 92 of the bladder 58 to the plug 98. The inlet opening 88 of the diaphragm bladder 58 is clamped to a ribbed end 110 of the inlet plug 98 with at least one clamping device 116. An o-ring 118 located around a center portion of the plug 98 seals the connection between the plug 98 and the end cap 96. An opening 120 extending through the inlet plug 98 allows water to flow through the plug 98 to the center pipe 56 within the bladder 58.

FIGS. 7 and 8 illustrate the outlet end 42 of the tank 12. FIG. 7 is an enlarged partial cross-sectional view of the outlet end 42 of the tank 12, while FIG. 8 is an enlarged view of an outlet end cap 124 that connects the outlet end 42 of the tank 12 to the tank outlet drop pipe 44.

The outlet end cap 124 includes a top flange 126 for enclosing the outlet end 42 of the tank 12, a center portion 128 for securing the outlet end cap 124 to the outer sidewall 54, and a bottom portion 130 for connecting the outlet end cap 124 to an outlet end 94 of the bladder 58. The center portion 128 having threads embedded therein for mating with threads on the inner surface of a top portion 132 of the outer sidewall 54. The bottom portion 130 having ribs 134 for securing the outlet end 94 of the bladder 58 to the outlet end cap 124. At least one clamping device 136 fits over the ribs 134 of the bottom portion 130 to secure the outlet end 94 of the bladder 58 to the outlet end cap 124. The outlet opening 90 of the diaphragm bladder 58 is clamped to a ribbed end 42 of the outlet end cap 124 with at least one clamping device 136.

The top flange 126 has connections 138, 140 for connecting the outlet end 42 of the tank 12 to the tank outlet drop pipe 44 and a pressure switch 22. The bottom portion 130 of the outlet end cap 124 has a connection 142 for connecting to the center pipe 56 within the bladder 58. A first opening 144 extending through the outlet end cap 124 between the center pipe connection 142 and the second drop pipe connection 138 allows water to flow from the center pipe 56 within the bladder 58 through the outlet end cap 124 to the tank outlet drop pipe 44. A second opening 146 extending through the flange 126 and the center portion 128 of the outlet end cap 124 allows pressurized air to flow from the pressure tank 12 to the pressure switch 22. An o-ring 148 located on an inner portion of the top flange 126 seals the outlet end cap 124 to the sidewall 54 of the outlet end 42 of the tank 12.

Referring again to FIG. 4, the flexible diaphragm bladder 58 is connected between the inlet plug 98 and the outlet end cap 124. The inlet end 92 of the bladder 58 is clamped to ribs 114 on the second end 110 of the inlet plug 98 with at least one clamping device 116. The outlet end 94 of the bladder 58 is clamped to ribs 134 on the bottom portion 130 of the outlet end cap

124 with at least one similar clamping device 136. The center pipe 56 extends through the center of the flexible diaphragm bladder 58 between the inlet end 92 and the outlet 94. The center pipe 56 has a plurality of holes 66 therein to allow water to flow into and out of the flexible bladder 58. Pressurized air fills an inner space 60 between the bladder 58 and the outer sidewall 54 of the tank 12. The components of the pressure tank 12 are preferably made out of a non-corrosive sanitary material, such as plastic or PVC to eliminate corrosion and bacterial growth. The flexible diaphragm bladder 58 is preferably made out of butyl rubber.

FIGS. 9A and 9B illustrate another embodiment of attaching and sealing the flexible diaphragm bladder 58 to the outer sidewall 54 and the inlet 40 and outlet 42 ends of the pressure tank 12. The pressure tank 12 is preferably installed within the well casing 14 of a well. The flexible diaphragm bladder 58 preferably includes an inlet end 92 with an inlet opening 88 and an outlet end 94 with an outlet opening 90. The inlet 92 end of the bladder 58 is sealed between a flexible inlet fitting 150 that forms the end cap 154 of the tank and is secured in place by a fastener assembly 158 that connects to the first drop pipe 38. An o-ring 160 seals the end cap 154 to the top of the sidewall 54. Likewise, the outlet end 94 of the bladder 58 is sealed between a flexible outlet fitting 152 that forms the end cap 156 of the tank and is secured in place by a fastener assembly 160 that connects to the second drop pipe 44. An o-ring 162 seals the end cap 156 to the top of the sidewall 54. This embodiment allows for easy repair and/or replacement of the bladder. The bladder is removed by removing the fastener assemblies 158, 160, removing the fittings 150, 152, and lifting the bladder 58 out.

FIGS. 10A and 10B illustrate another embodiment of a water pressure system 170 having a pressure tank 164 installed within the well casing 166 of a well 168, the pressure tank 164 having no center pipe with water stored on the outside of a flexible diaphragm bladder 172, the

pressure tank 164 connecting to a control valve 174, a relief valve 176, and a submersible pump 178. FIG. 10A shows the bladder of the tank at maximum storage capacity, while FIG. 10B shows the bladder of the tank at minimum storage capacity.

The water pressure system 170 of FIGS. 10A and 10B, comprises a submersible pump 178 installed in a well 168 for pumping water from a water bearing aquifer 180 through a relief valve 176, a flow control valve 174 to a pressure tank 164 installed in the well casing 166 of the well 168.

The output 182 of the submersible pump 178 is connected to the relief valve 176. The relief valve 176 is preferably installed below the pumping water level 184 right above the submersible pump 178, so that the relief valve 176 is always under water, preventing mineral deposits from forming on the relief valve 176 that could adversely affect water quality. The relief valve 176 releases excess pressure in the system and limits back pressure from building up in the submersible pump, especially on the motor bearings of the pump, which could fail if the relief valve was not installed in the system. A first drop pipe 186 preferably connects the relief valve 176 to the flow control valve 174. The flow control valve 174 controls output flow from the pump 178 and relief valve 176. The flow control valve 174 maintains constant water pressure in the system and automatically adjusts the pump's output to match the flow requirements of the system. The flow control valve 174 also extends pump life by eliminating pump cycling, eliminating changes in water pressure and eliminating the need for a large storage pressure tank. A tank inlet drop pipe 188 connects the flow control valve 174 to the inlet end 190 of the pressure tank 164. A tank outlet drop pipe 192 preferably connects the outlet end 194 of the pressure tank 164 to a discharge pipe (not shown) for distributing pressurized water from the pressure tank.

The pressure tank 164 comprises an outer sidewall 196 with an inlet end 190 and an outlet end 194, a flexible diaphragm bladder 172, and a confining tube 198 for supporting the flexible diaphragm bladder 172 in the tank. The inlet end 190 and the outlet end 194 are sealed to the outer sidewall 196 at both ends of the pressure tank 164. The flexible diaphragm bladder 172 includes an inlet end 200 with an inlet opening 202 and an outlet end 204 with an outlet opening 206. An inlet end plug 208 seals the inlet end 200 and inlet opening 202 of the flexible diaphragm bladder 172. An outlet end plug 210 seals the outlet end 204 and outlet opening 206 of the flexible diaphragm bladder 172. The confining tube 198 prevents the bladder 172 from over expanding and allows a passage for water around the bladder when it is fully expanded. An air chamber 212 exists on the inside of the flexible diaphragm bladder 172, and a water chamber 214 exists between the confining tube 198 and the outer sidewall 196. An air valve 216 extending through the tank outlet drop pipe 192 and the outlet end plug 210 allows adjustment of air pressure in the bladder 172. At least one bracket 218 attaches the bladder ends and plugs to the outer shell of the tank and hold the bladder secure in the pressure tank. The brackets are constructed to allow water to pass through and around them. At least one strap attaches the bladder to the plugs at each end of the bladder. The straps are preferably stainless steel. The bladder is preferably made out of butyl or other FDA or LNSF approved material. The outer shell of the tank can be made of plastic or other non-corrosive material such as stainless steel. An anchor system 220 attaches the bottom end of the bladder and plug to keep the bladder from moving to the top of the pressure tank.

In FIG. 10A, the water pressure has the air on the inside of the bladder compressed. In FIG. 10B, the bladder is expanded to the confining tube. This tube prevents the bladder from over expanding and sealing off movement of water.

FIGS. 11A and 11B illustrate another embodiment of a water pressure system having a pressure tank installed within the well casing of a well, the pressure tank having no center tube with water on the outside of the bladder, the pressure tank connecting to a control valve with an integral relief valve incorporated therein and a submersible pump. FIG. 11A shows the bladder of the tank at maximum storage capacity, while FIG. 11B shows the bladder of the tank at minimum storage capacity.

The output 28 of the submersible pump 18 is connected to the flow control valve 76 with integral relief valve 78. The flow control valve 76 with integral relief valve 78 is preferably installed below the pumping water level 24 right above the submersible pump 18, so that the flow control valve 76 with integral relief valve 78 is always under water, preventing mineral deposits from forming on the relief valve 78 that could adversely affect water quality. The relief valve 78 releases excess pressure in the system and limits back pressure from building up in the submersible pump, especially on the motor bearings of the pump, which could fail if the relief valve was not installed in the system. The flow control valve 76 controls output flow from the pump 18. The flow control valve 76 maintains constant water pressure in the system and automatically adjusts the pump's output to match the flow requirements of the system. The flow control valve 76 also extends pump life by eliminating pump cycling, eliminating changes in water pressure and eliminating the need for a large storage pressure tank. A tank inlet drop pipe 38 connects the flow control valve 76 with integral relief valve 78 to the inlet end 40 of the pressure tank 12. A tank outlet drop pipe 44 preferably connects the outlet end 42 of the pressure tank 12 to a discharge pipe (not shown) for distributing pressurized water from the pressure tank 12.

The pressure tank is the same as that shown in FIGS. 10A and 10B.

FIGS. 12A and 12B illustrate another embodiment of a water pressure system having a pressure tank installed within the well casing of a well, the pressure tank having no center tube with water on the outside of the bladder, the pressure tank connecting to a variable speed submersible pump. FIG. 12A shows the bladder of the tank at maximum storage capacity, while FIG. 12B shows the bladder of the tank at minimum storage capacity.

The water pressure system of FIGS. 12A and 12B, comprises a submersible variable speed pump 82 installed in a well 16 for pumping water from a water bearing aquifer 20 to a pressure tank 12 installed in the well casing 14 of the well 16 for distribution and use. A tank inlet drop pipe 38 preferably connects the output 84 of the submersible variable speed pump 82 to the inlet end 40 of the pressure tank 12. A tank outlet drop pipe 44 preferably connects the outlet end 42 of the pressure tank 12 to a discharge pipe (not shown) for distributing pressurized water from the pressure tank 12.

The pressure tank is the same as that shown in FIGS. 10A and 10B.

FIG. 13 is a cross-sectional view of the pressure tank of FIGS. 10A, 10B, 11A, 11B, 12A and 12B taken along line 13-13 of FIG. 10A.

While the invention has been described with reference to preferred embodiments, those skilled in the art will appreciate that certain substitutions, alterations and omissions may be made without departing from the spirit of the invention. Accordingly, the foregoing description is meant to be exemplary only, and should not limit the scope of the invention set forth in the following claims.